Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

A280.39
M34Amo
Cop. 2

AMS-439

UNITED STATES DEPARTMENT OF AGRICULTURE
Agricultural Marketing Service
Market Quality Research Division

U.S. D [illegible] ULTURE
C [illegible]

CONTROLLING THE CIGARETTE BEETLE IN THE TROPICS

Joseph N. Tenhet [1]

SAFEGUARDS IN FUMIGATION

1. Before you fumigate, notify the fire-insurance underwriters of your intention to do so, and get their approval of the procedure.

2. Notify local authorities also, and obtain permits from them. Notify them again when the fumigation is completed and the building has been properly ventilated.

3. Hire only trained men, preferably licensed pest-control operators, to fumigate warehouses and factories. Because of the danger in working with poison gas, it is extremely important that operators abstain from intoxicants.

4. Disconnect all telephone and electric lines into the building or chamber, from outside the building if possible, except where electric fans are used. Use only spark-proof and explosion-proof electric fans. Turn off all pilot lights and hot water heaters.

5. Wear or carry gas masks equipped with the proper cannisters at all times when handling gas.

6. Keep all persons and animals outside the building or chamber while it is closed and sealed for fumigation. Post placards in prominent places on the building or chamber, warning that it is being fumigated with poison gas.

7. Keep guards and night watchmen on duty to see that no person or animal approaches a building under fumigation.

---

[1] Mr. Tenhet is stationed at Richmond, Va., with the Stored-Product Insects Branch, U. S. Department of Agriculture.

Washington, D. C. April 1961

CONTENTS

Page
Summary.. 4

Introduction... 5

Life history of the cigarette beetle............................. 6

Sanitation in preventing insect attack........................... 7

    Tobacco storage and processing plants........................ 7
    Cigar factories.. 8
    Storage bins... 9

Insect traps... 9

Method of fumigation... 10

    Vacuum chambers.. 11
    Atmospheric chambers... 12
    Warehouse or space fumigation................................ 15
    Tarpaulins... 16

Sealing for fumigation... 16

Preparation of bales for fumigation.............................. 19

Storage of tobacco after fumigation.............................. 19

Fumigants.. 20

    Hydrogen cyanide... 20
    Methyl bromide... 20
    Acrylonitrile-carbon tetrachloride 34-66 (by volume)......... 21
    Ethylene oxide-carbon dioxide 1-9............................ 21
    Carbon disulphide.. 22
    Dosages and exposures.. 22

Space treatments... 22

    Pyrethrum mists and aerosols................................. 22
    DDVP... 25

Control with temperature... 26

    Cold and cool storage.. 26
    Heat... 27

Literature Cited... 29

SUMMARY

The cigarette beetle (Lasioderma serricorne (F.)) is a serious pest of cured tobacco throughout the world. In the tropics its ecology and biology differ slightly from that in the temperate zone. In the tropics the life cycle is approximately 50 days, and there may be six or more generations a year.

In preventing beetle attack the most important points are sanitation, segregation of infested tobacco, and complete use of stocks before replacement.

Knowledge of location and intensity of infestation can be obtained through the use of insect traps. The most satisfactory type of trap is the suction-light trap.

One of the most common methods of insect control in stored tobacco is by means of fumigation. Fumigation may be in vacuum chambers, atmospheric chambers, in entire warehouses, or under tarpaulins. Vacuum fumigation is rapid and completely effective but very expensive. Atmospheric chamber fumigation is slow, satisfactorily effective, and cheaper. Warehouse or space fumigation is relatively fast and cheap, but it is the least efficient. Small lots of tobacco may be fumigated under tarpaulins.

Of the commonly used fumigants, HCN is effective, but temporarily leaves an undesirable odor and flavor on the tobacco. Methyl bromide is equally as effective, and is usually harmless to tobacco. However, on rare occasions the bromine may react with certain tobaccos to produce objectionable odors. Being accumulative in the human body for short periods, it is also more treacherous to handle. Acrylonitrile-carbon tetrachloride 34-66 is effective, leaves no odor on tobacco, and is relatively safe to handle. However, it corrodes metal and attacks rubber. Ethylene oxide-carbon dioxide (1:9) leaves no odor on tobacco but is very expensive, and is erratic in effectiveness. Carbon bisulphide is not recommended because of explosion and fire hazard.

Dosages and exposures are suggested for each type of fumigation, for different fumigants, and for different kinds of tobacco.

The effectiveness of fumigation depends primarily upon the sealing of the chamber or building, and upon the ability of the gas to penetrate the tobacco. Suggestions are made for locating leaks, methods of sealing, and methods of packing bales to facilitate fumigation.

Where fumigation is impractical, insecticidal mists and aerosols may be used effectively to kill those beetles in the air. Effectiveness of such treatment depends upon systematic applications in order to kill the beetles before eggs are deposited. Pyrethrum is safe to use, but kills only at the time of application. DDVP kills by contact, and releases a vapor which, in closed buildings, continues to kill for 3 or 4 days. However, DDVP is dangerous to apply, and it should be applied by pest control operators.

When sweated tobaccos must be held for appreciable periods of time, the most satisfactory method of preventing insect attack is by storing the tobacco at low temperatures. The beetle is not active at temperatures below 60° F. Temperatures below 50° will cause death.

Cold is an efficient and safe substitute for fumigation. At -10° F., insect infestation in bales and cases is destroyed in 3 to 5 days.

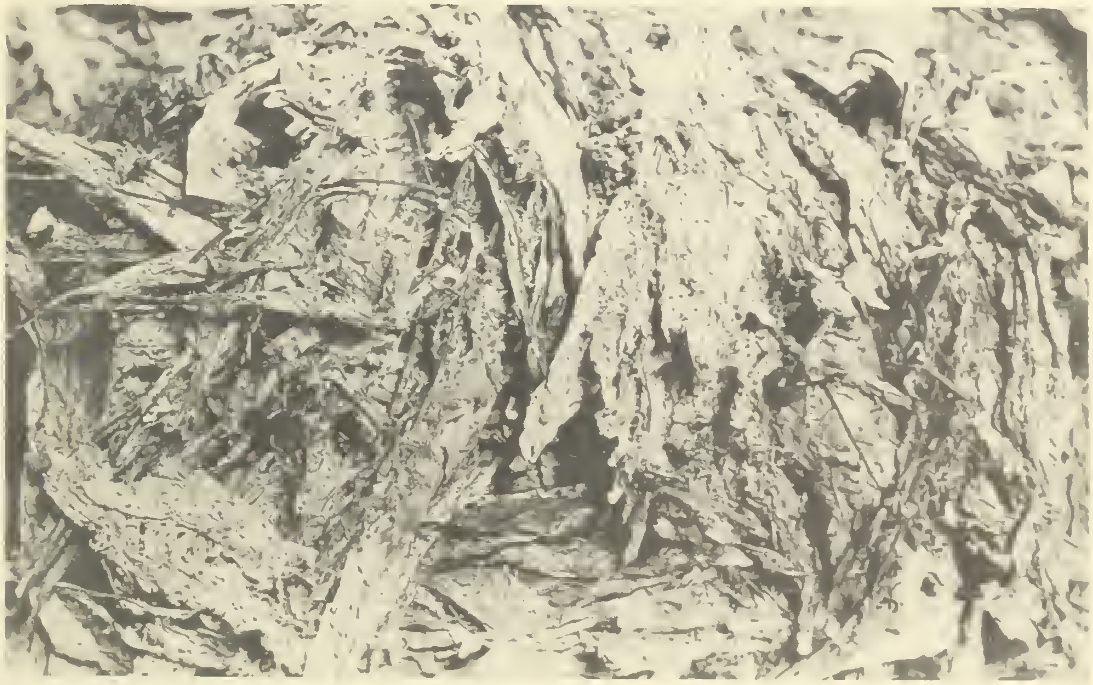
Heat is also effective in destroying beetle infestation. In bales of filler, steam sometimes may be used to advantage just prior to manufacture.

INTRODUCTION

Cured tobacco is attacked by the cigarette beetle (Lasioderma serricorne, (F.)) throughout the world. Raw and "sweated" leaf strips and finished cigars are all attacked (figs. 1 and 2).

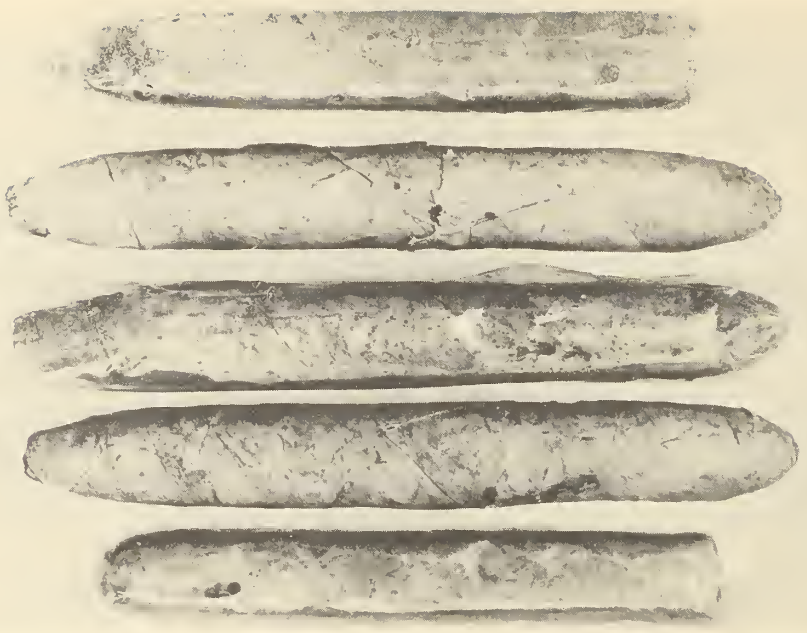
Damage by this insect is especially prevalent in the West Indies. Many of the measures for controlling the beetle in the tropics are the same as those used in temperate zones, but some are quite different. In the tropics, the insect is active throughout the entire year; it has more generations and a shorter life cycle.

The curing, storing, processing, and manufacturing of tobacco is one of the oldest and largest of industries. Losses from attack by the cigarette beetle are constant and are often serious. In some instances, the success of a business firm has been imperiled by such losses. Consequently, control of the insect is of vital interest to the tobacco industry.



BN-8718

Figure 1.--Leaf tobacco damaged by the cigarette beetle.



BN-8717

Figure 2.--Cigars damaged by the cigarette beetle.

LIFE HISTORY OF THE CIGARETTE BEETLE

The cigarette beetle is a small brown beetle approximately 2 to 3 mm. long (3).[2] The adults live 10 days to 3 weeks, and the females lay most of their eggs within 5 days after they emerge. About 50 percent of the beetles are females, and, on the average, they lay about 40 to 50 eggs (1, 3, 4, 5, 11).

In about a week the egg hatches into a whitish larva, or grub, which immediately begins feeding. When first hatched, the larva is scarcely visible to the naked eye. When full grown, in 30 to 35 days, it is approximately 3 mm. long. The larva changes into a pupa--a resting stage--and, in about another week, the pupa changes into the beetle. The entire life cycle is approximately 50 days, but it may be shorter.

This beetle is a good flier. It readily flies one-half mile, and under favorable conditions it may fly more than a mile. Flight is usually in the late afternoon and early night (7); the flying beetles are attracted to lights. The adult beetle does not feed, and does not cut its way into packages or containers of food. It does cut its way out of such places. Holes in packages or in cellophane wrappers are exit holes, not entrance holes. Most of the damage caused by the cigarette beetle is the result of feeding by the larvae or grubs.

---

[2] Underlined figures in parentheses refer to Literature Cited, page 29.

This tiny insect can breed in minute amounts of tobacco scrap or dust. It also breeds in other materials such as beans, peas, grains, cereals, peanuts, cocoa, red pepper, spices, cottonseed meal, animal feeds, broom corn, woolen cloth, various kinds of fiber, and even leather (3).

In the temperate zones and in most of the United States, there are one to three generations of the beetle a year. The winter is passed in the larval stage, and there is little or no activity when tobacco temperatures are below 60° - 65° F. In the tropics, there may be six or more generations a year (4) because there is no dormant period.

In temperate climates, there are more or less distinct broods or peaks of adult emergence; in North Carolina and Virginia there are usually three per year. Later broods overlap somewhat. Distinct broods are rarely observed in the tropics. The generations overlap so that all stages of development may be constantly present.

In the United States fumigation is often timed to follow the peak of brood emergence. This is not practical in the tropics.

SANITATION IN PREVENTING INSECT ATTACK

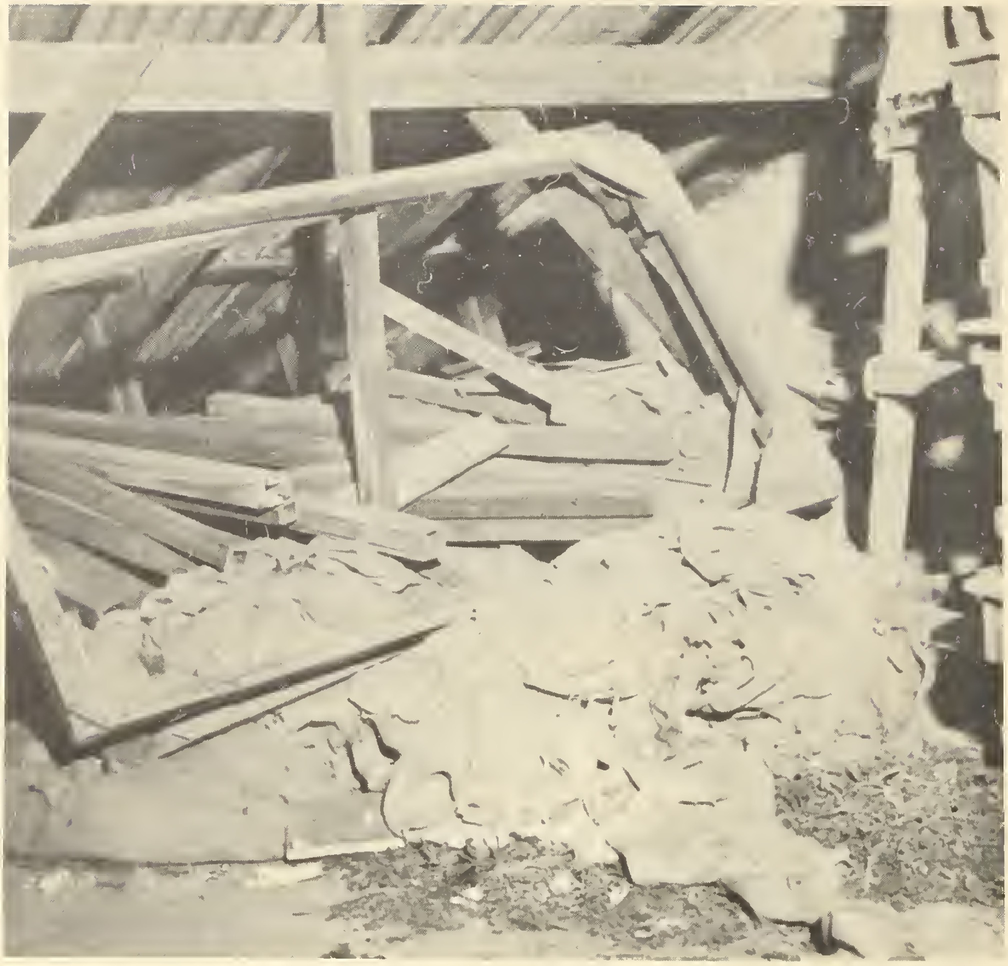
It is much cheaper and simpler to avoid insect damage in tobacco than to try to control an infestation after it has developed. Since this little beetle can breed in minute quantities of material, warehouse and factory sanitation cannot be overemphasized.

Tobacco Storage and Processing Plants

When tobacco is being processed and stored, the area should be cleaned at least weekly, and daily when possible. All tobacco scrap and sweepings should be removed from the premises and fumigated, burned, or scattered thinly over the soil a mile or more from the building.

During the inactive season, burlap-covered frames, old burlap, tables, and benches used in stripping and grading are often stored in the attic or seldom-used areas of the processing plant. These areas often harbor old tobacco scrap and usually contain tobacco dust and particles of tobacco leaf in cracks or crevices (fig. 3). They may provide breeding grounds for the cigarette beetle.

Equipment should be cleaned thoroughly before it is stored, and fumigated when possible. Also all areas where such equipment has been stored should be carefully cleaned. Wooden false flooring over concrete floors should be removed, and trash and dust cleaned from cracks and crevices. Scale pits and enclosed spaces under machinery and cabinets should be opened and cleaned out. When practical, the interior walls and ceilings of the building should be brushed down and scrubbed.



BN-8716

Figure 3.--Accumulated litter, old burlap, and tobacco scrap under the eaves of a tobacco processing plant.

The interior walls, floors, and ceilings should be sprayed with 5 percent DDT, if the premises are cleaned when tobacco is not being stored or worked. Either DDT emulsion or wettable powder may be used, but the wettable powder is preferred. The DDT is applied as a coarse wet spray, and all surfaces should be wetted almost to the runoff point. The residual deposit from the spray will remain effective for a month or more. CARE SHOULD BE TAKEN NOT TO APPLY DDT SPRAY WHERE IT WILL COME IN CONTACT WITH UNPROTECTED TOBACCO.

Cigar Factories

Sanitation is even more important in cigar factories than in tobacco storages and processing plants. A few beetles flying around can lay eggs on many cigars. Factories should be cleaned daily, and all waste tobacco scrap and sweepings should be destroyed immediately.

Every precaution should be taken to prevent bringing infested tobacco into a cigar factory. Moreover, it should be taken for granted that practically all lots of tobacco are more or less infested.

Infested tobacco should never be taken directly into the manufacturing area. One way to avoid doing this is to have a receiving room. All tobacco brought into the factory should be held in a room or separate building, screened with 20-mesh wire or plastic gauze, until it can be fumigated or otherwise treated. Such a receiving room should have tight walls; all doors, windows, and ventilating areas should be tightly screened. The doors should be kept closed at all times except when actually in use. A receiving room in a factory building should have a large electric fan mounted to blow air from the factory into the room. The force of air will prevent beetles flying through the open door into the factory.

Storage Bins

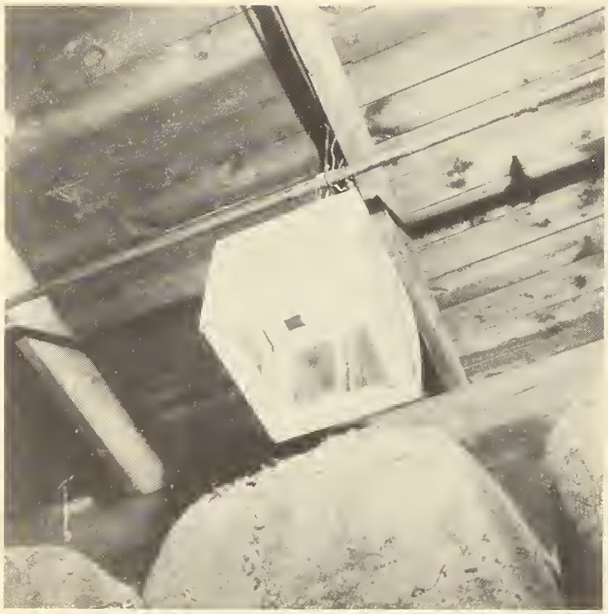
Scrap filler left in storage bins is a common source of insect infestation. Some of these bins are rarely, if ever, completely emptied. The bin is refilled as soon as about three-fourths of the contents is used. Therefore, the small amount of tobacco remaining at the bottom of the bin is never used and becomes a breeding ground for beetles. Enough bins should be provided so that each one can be emptied completely and cleaned carefully before it is refilled. An industrial vacuum cleaner will suck all particles of tobacco dust from cracks and crevices. Such a cleaner is also invaluable for cleaning machines, benches, and cabinets in the factory.

INSECT TRAPS

The first step in protecting tobacco from beetles is to know where they are. One of the most satisfactory methods of accomplishing this is to use insect traps. Various types of traps can be used. The most common are the sticky-paper light trap and the suction-light trap.

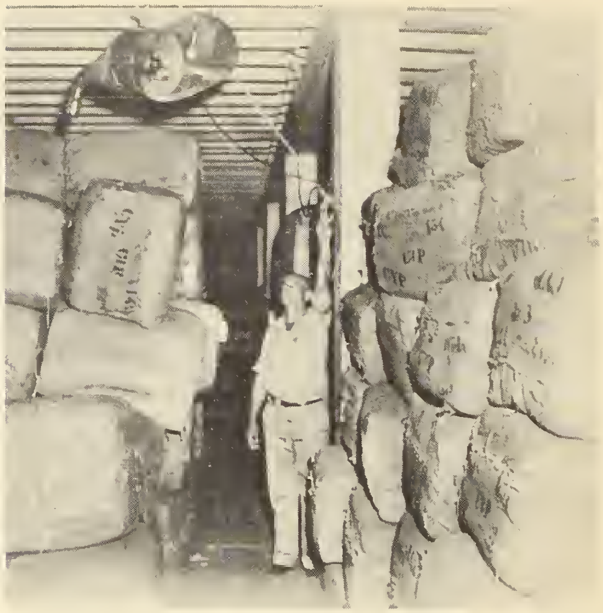
The sticky-paper light trap is cheap and simple but is not very efficient; it is effective only when the paper is changed weekly (fig. 4). The best traps are constructed as a cubical wooden frame with each side approximately 1 foot square. The sticky paper is fastened to four sides of the frame with thumb tacks. This trap has a 50- or 60-watt electric light bulb inside it and is suspended near the ceiling. The light shining through the translucent paper attracts the beetles, and they are trapped when they strike the sticky surface (2).

The suction-light trap is much better (fig. 5). This trap is widely used in the United States. A 50- or 60-watt bulb should be used in these traps. They should be operated continuously 24 hours a day, and the number of beetles captured should be recorded at least once a week. In a cigar factory, daily counts may be desirable.



BN-8715

Figure 4.--One type of sticky-paper insect trap in tobacco warehouse.



BN-8714

Figure 5.--Suction-light insect trap in tobacco storage.

Traps equipped with "black light" (radiant energy between 3,200 and 4,000 angstroms) or fluorescent bulbs will attract more beetles than those using the standard incandescent light bulb. Even these traps have only limited value in tobacco warehouses because only a very small percentage of the beetles will be trapped.

The chief value of a trap is to show where and when the beetles are present, and the standard trap does this satisfactorily. One trap is sufficient for even a large storage room. However, in a factory or processing plant, it is desirable to have one trap in every room or area where tobacco is stored or processed. In such buildings, where even a few beetles are a serious problem, black-light suction insect traps can be valuable as an aid to control.

Traps should be centrally located near the ceiling, at least 1 or 2 feet above the top of the highest stacks of tobacco, and should be mounted on ropes and pulleys so they can be easily lowered for examination.

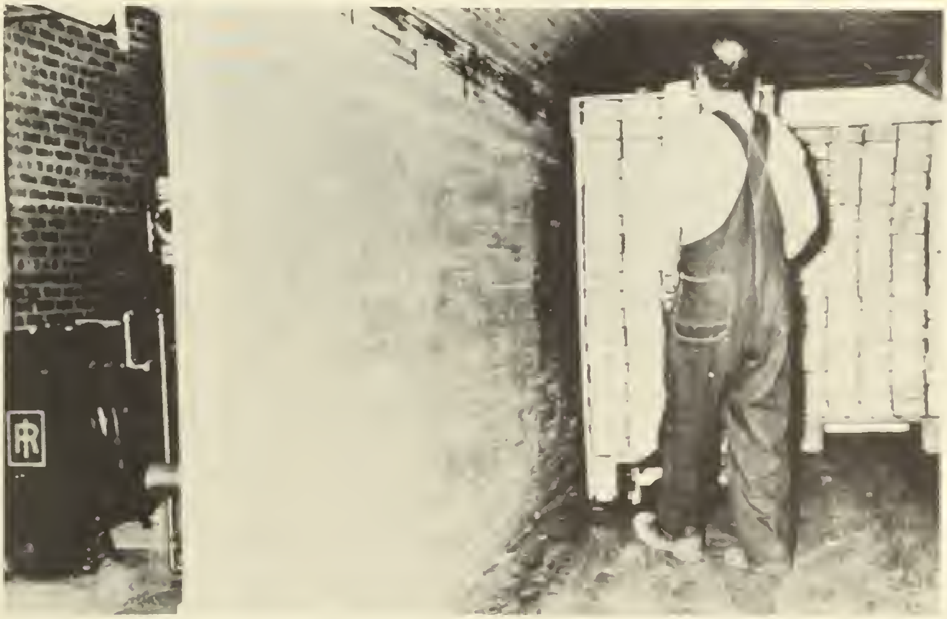
METHODS OF FUMIGATION

Fumigation is one of the simplest and best-known methods of killing insects in tobacco. There are four types of fumigation--vacuum, atmospheric chamber, warehouse or space, and tarpaulin--each of which has certain advantages and disadvantages. All require the use of a gas which is lethal to all stages of the beetles. When properly used, a fumigant will penetrate a mass of tobacco, killing the eggs, larvae, pupae, and adults. The depth of penetration of the gas, however, depends upon the method of fumigation, the fumigant used, the dosage of fumigant, the exposure period, the tightness of the chamber or building, the covering on the bales or boxes, and the method of stacking the units of tobacco (figs. 6 and 10).

Most fumigants are explosive at high concentrations. However, the dosages suggested in this paper are within the safety limits of explosive or flammable concentration.

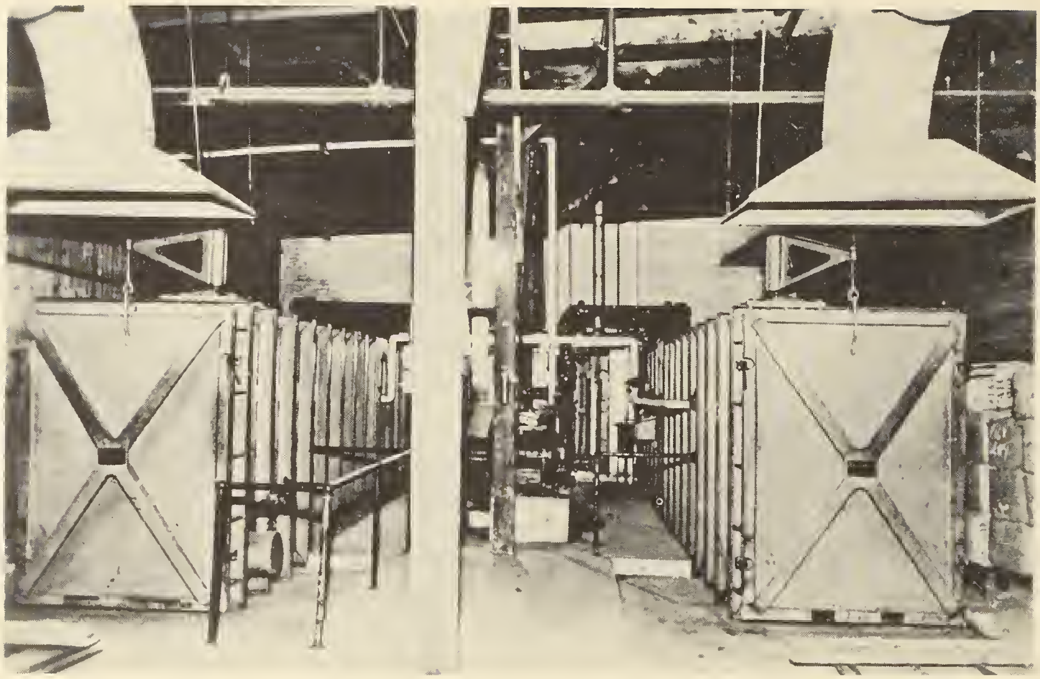
Vacuum Chambers

Vacuum fumigation requires the use of steel chambers. Such chambers may vary in capacity from 200 to 5,000 cubic feet, and are usually in pairs, both of them being operated by a single compressor (fig. 7). When loading a vacuum chamber, the bales, cases, or boxes should be on a pallet or dunnage; a few inches of airspace should be left above, below, and on all sides of the tobacco. Vacuum chambers should never be overcrowded (fig. 6). The chamber should be evacuated to a pressure of not less than 28 inches on a standard mercury gage (2 inches or less of absolute pressure). The fumigant is then introduced into the chamber, and the chamber is held under sustained vacuum for 4 hours (8). At the end of the 4 hours, the vacuum is released, and the tobacco is air washed twice by again evacuating the air from the chamber and releasing the vacuum.



BN-8712

Figure 6.--Loading a vacuum fumigation chamber. Cigar boxes are loosely stacked; ample airspace is left above and below.



BN-8713

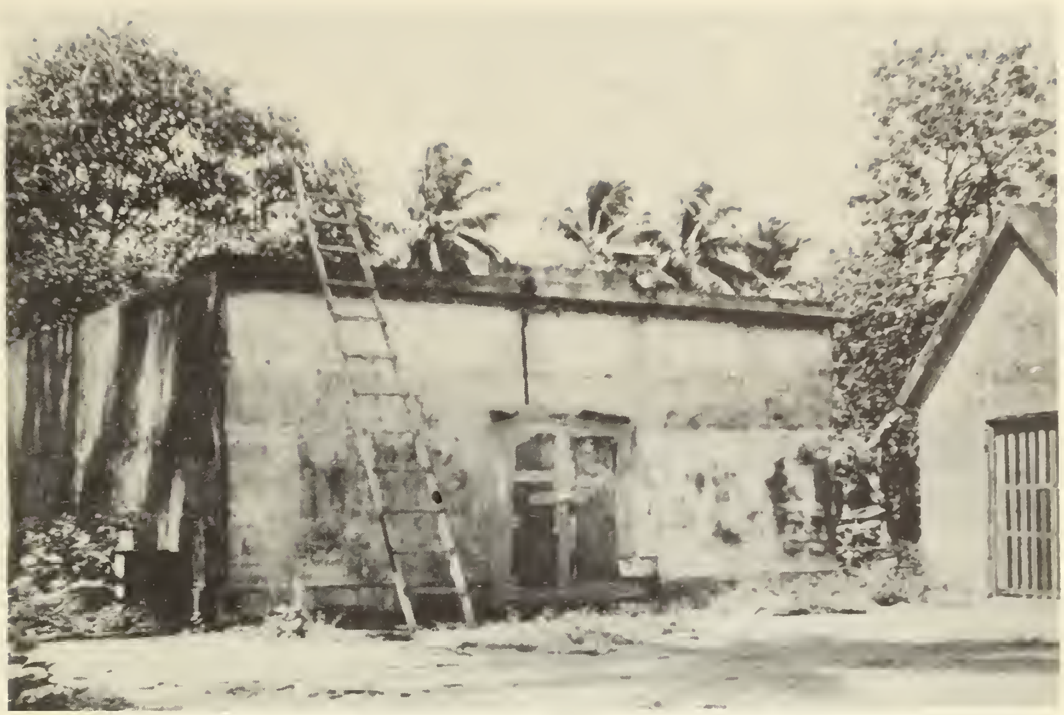
Figure 7.--A pair of industrial vacuum fumigation chambers.

The advantages of vacuum fumigation are rapidity of the process and complete effectiveness. When properly performed, such fumigation kills all insect life at all depths in the tobacco. It is the only method of fumigation which can be depended upon to be 100 percent effective for most products. Bales, cases, cartons sealed with gummed tape, bales of shade wrapper, even cellophaned and boxed cigars may be fumigated effectively. The only containers which cannot be fumigated satisfactorily in vaccum are: (1) vacuum-sealed tins and (2) cellophaned and boxed cigars with the box overwrapped with cellophane. The latter unit is so tight that, even in vacuum fumigation, gas does not penetrate well.

The disadvantages of vacuum fumigation are the high cost of the equipment, high cost of operation, and small capacity of the chambers.

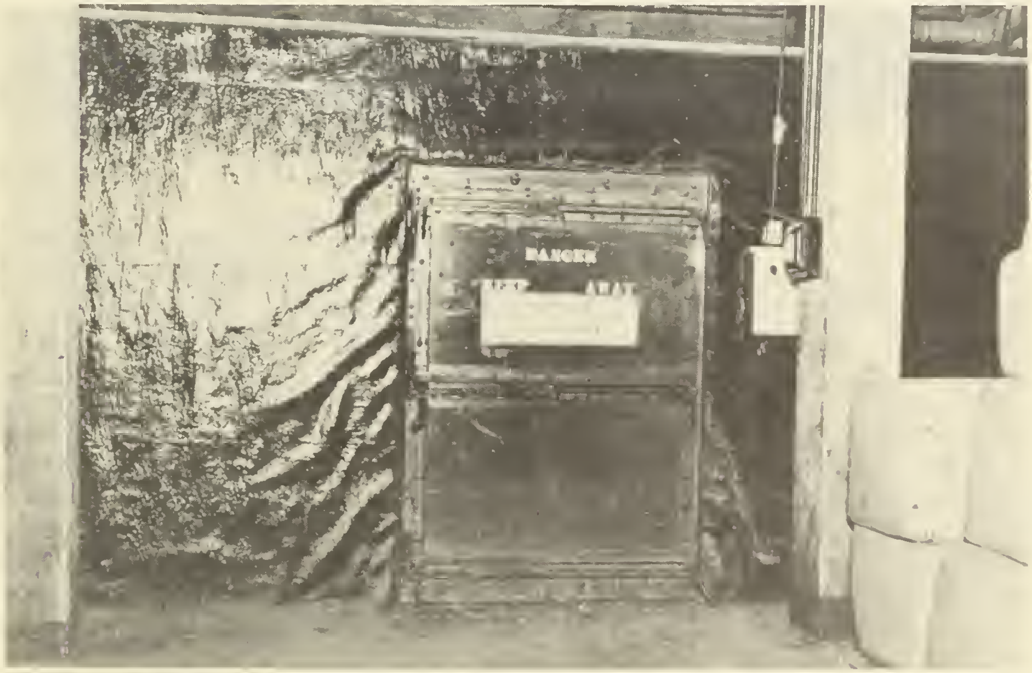
Atmospheric Chambers

Atmospheric chambers have long been popular in Puerto Rico. This treatment merely requires a tight room or chamber (fig. 8). However, a chamber especially designed for fumigation is most desirable. This chamber should: be permanently sealed; have a refrigerator-type door that makes close contact against a gasket at all points (fig. 9); have means of introducing the fumigant from the outside of the chamber; be equipped with one or more electric fans with spark- and explosion-proof motors; and have an air-intake valve near one end of the chamber and a vent discharging near the other end, above the roof of the building. The air-intake and the vent



BN-8711

Figure 8.--An atmospheric fumigation chamber in Puerto Rico.

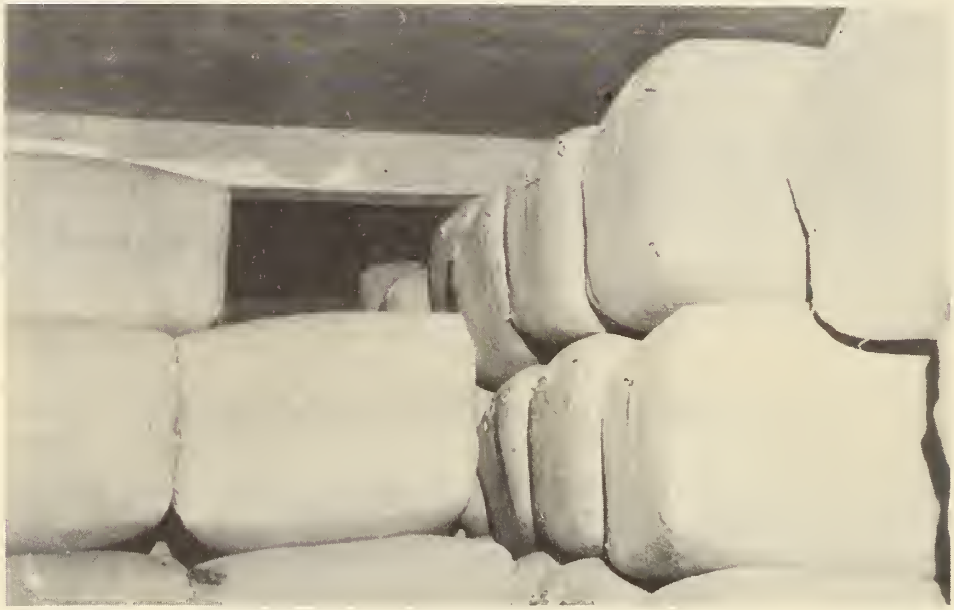


BN-8708

Figure 9.--A well-built atmospheric chamber, illustrating the use of a refrigerator type door.

should be equipped with a valve operated from outside the chamber, and the vent should have a fan for exhausting residual gas from the chamber at the end of the fumigation (8). Atmospheric chambers may be of any size, but are usually from 5,000- to 25,000-cubic-foot capacity.

Fumigation in an atmospheric chamber is slower and is not quite as effective as in a vacuum chamber, but the initial cost is much less. When the atmospheric chamber is properly used, good results can be obtained. Unfortunately, results are sometimes poor. Usually this is due to: the chamber not being tight enough; the chamber being overcrowded with tobacco; insufficient airspace between the bales or cases (fig. 10); inadequate dosage of fumigant; or poor circulation of the gas within the chamber.



BN-8710

Figure 10.--An atmospheric fumigation chamber, showing overcrowding with bales of tobacco stacked too tightly together. Bales are not separated and almost touch the ceiling. Fumigation under such conditions cannot give satisfactory results.

For good results, it is essential to leave airspaces over, under, between, and around bales and cases. Preferably, bales should be stacked with strips of wood 2 inches thick between the tiers. If this is impractical, they should be stacked like bricks in a wall with a 2-inch space between bales in the same layer. Bales or cases should be stacked in rows not more than two bales or cases wide, and not more than four or five tiers high. They should be placed on pallets or dunnage to allow circulation of air beneath them. There should always be a space of 2 feet or more between the tops of the bales or cases and the ceiling. Alleys not less than 2 feet wide should be left between piles of bales and cases. An alley wide enough to permit easy access for loading and unloading the chamber should be left directly in front of the door.

Fans for circulating the gas in the chamber should be mounted near the ceiling and directed to blow downward at an angle. Such fans will prevent stratification of the gas, improve its distribution, and insure more uniform effectiveness. One 14- or 16-inch electric fan to 20,000 cubic feet is sufficient. If the fumigant is HCN or methyl bromide, the fans should be operated for 1 hour at the start of a fumigation in order to circulate the gas in the chamber; if acrylonitrile-carbon tetrachloride is used, the fans should be operated 4 to 6 hours.

PRIOR TO THE START OF THE FUMIGATION, THE DOOR OF THE CHAMBER SHOULD BE PADLOCKED TO PREVENT ACCIDENTAL ENTRANCE. THE DOOR SHOULD BE KEPT LOCKED THROUGHOUT THE FUMIGATION PERIOD.

At the end of the fumigation, the valves of the air-intake and the exhaust system should be opened, and the exhaust fan operated for several hours before the door of the chamber is opened. Laborers should not enter the chamber until it is aerated for at least 12 hours. Even then, it is desirable to continue operating the exhaust fan while laborers are unloading the chamber. This will provide a movement of air into the chamber through the open door and away from the laborers. During fumigation some of the gas is absorbed by the tobacco. Following fumigation this absorbed gas is gradually released. Breathing even small quantities of gas is dangerous. Hence, the continuing operation of the exhaust fan is an excellent safety precaution.

It is most desirable to have every atmospheric chamber equipped with vents and an exhaust fan. If a chamber is not so equipped, it should be opened and aerated for at least 24 to 36 hours before being entered. During the latter part of this period, aeration and elimination of gas pockets may be hastened by the use of electric fans placed in a door, window, or ventilator, blowing air out of the chamber.

Warehouse or Space Fumigation

In warehouse or space fumigation, an entire warehouse, factory, or a part of a manufacturing plant is sealed up and fumigated. Large quantities of tobacco may be treated rapidly and with relative economy. The chief difficulty is in sealing large buildings well enough to maintain a high concentration of gas.

Consequently, warehouse or factory fumigation is rarely as effective as could be desired. Because of the lower concentration of the fumigant, the gas does not penetrate the bales, cases, or bulks of tobacco as deeply as is needed, and as a result the insect infestation may be reduced, but is seldom eliminated.

Space fumigation of an entire building can be expected to reduce and retard the development of the insect infestation but nothing more. Warehouse fumigation is the cheapest form of fumigation, but it is usually the least efficient (8).

After a warehouse or factory has been fumigated, it should be thoroughly ventilated, and until it is well aired no one should enter the building unless wearing a gas mask. The seal should be broken and one or two doors and windows or ventilators opened. After about 12 hours of ventilation, the building may be entered and all windows and ventilators opened. However, no one should work in the building for any length of time until after at least 24 hours of ventilation. Even then care should be exercised. If a strong odor of fumigant is detected in any area or room, electric fans should be used to assist in ventilating. Laborers should not remain in such areas until they are relatively free of gas.

Tarpaulins

When tobacco is bulked for sweating, temperatures sometimes rise to 120°-130° F. These temperatures might kill cigarette beetles in the tobacco if the beetles were exposed to them for a prolonged period of time. However, that is rarely the case. Such temperatures are attained in the interior of the bulk, but the temperature is appreciably lower in the periphery. Most of the insect infestation, if not all of it, is usually found within the outer 2 or 3 inches of tobacco. We have never seen beetles die as a result of the high temperatures generated by sweating.

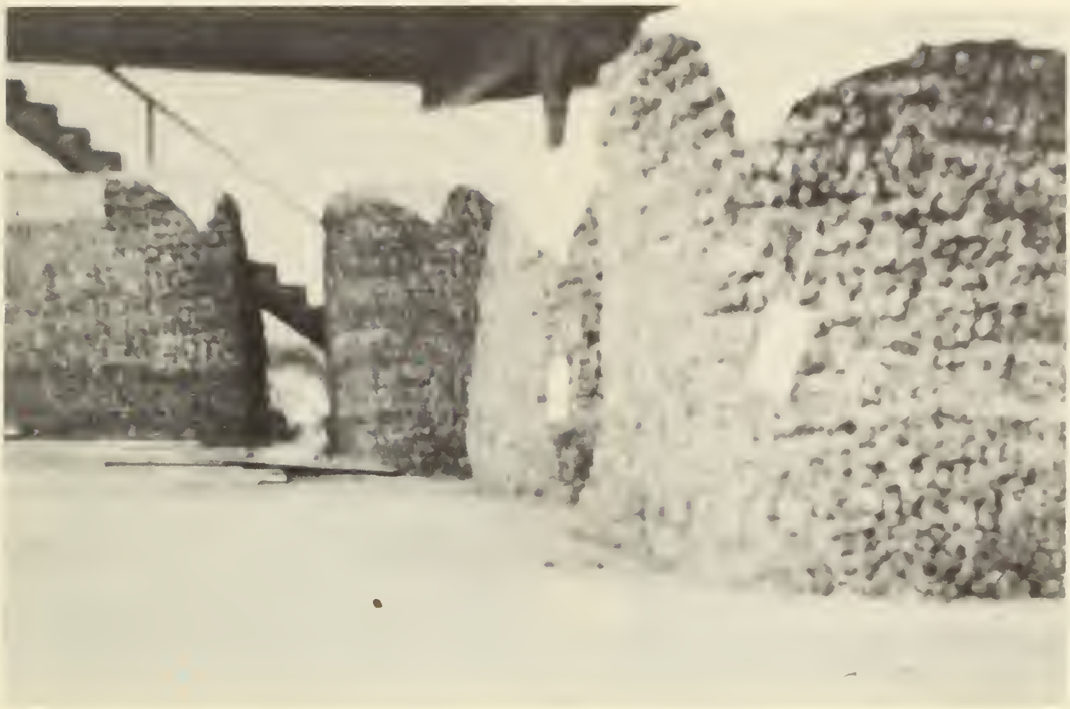
If desirable, tobacco in a bulk may be fumigated (fig. 11). A bulk or a pile of bales is covered with a tarpaulin and given an atmospheric fumigation. Polyethylene sheeting, 4 mils or more thick, is suitable. Widths of sheeting may be joined with masking tape. If the bulk is on a smooth tight flooring, such as concrete, the tarpaulin also may be readily sealed to a clean floor with masking tape.

It is not definitely known whether fumigation has any effect on cigar tobacco actually in sweat. However, flue-cured cigarette tobacco has been fumigated when in sweat, and cigar tobaccos have been fumigated with HCN or with methyl bromide before they are sweated, or when incompletely sweated, with no detectable effect upon later sweating.

SEALING FOR FUMIGATION

Sealing is necessary for successful fumigation of a tobacco warehouse, factory, or atmospheric chamber. Its importance can scarcely be overemphasized. The building or chamber must be rendered practically airtight. A building may be weather-tight and rain-tight, but still leak gas like a sieve.

Windows and doors must be carefully sealed with a heavy kraft paper. Polyethylene plastic sheeting of 4 mil thickness may be used in place of paper, but is slightly more expensive. The paper or plastic should be carefully sealed to the door or window frames with a good quality paper masking



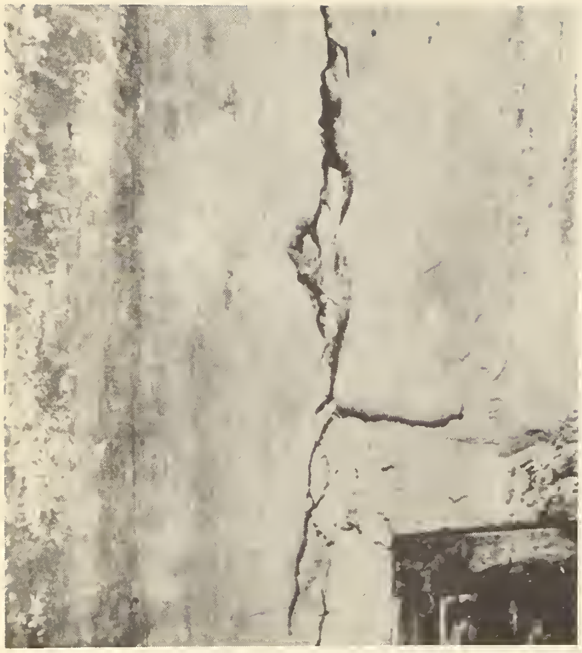
BN-8707

Figure 11.--Puerto Rican cigar tobacco in bulks.

tape. This is a pressure adhesive tape. For large doors or open windows, it is often necessary to build a wooden frame to be covered with paper and inserted into the opening. The most difficult places to seal are usually the eaves, flashings, ventilators, and skylights. Leaks in such areas often act like a chimney, carrying gas out of the building as fast as it is introduced.

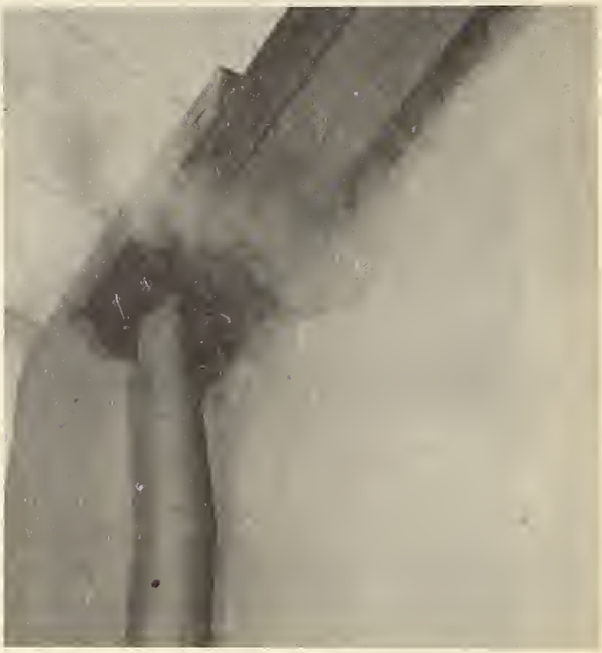
Masonry walls often develop cracks (fig. 12), and even when solid are often not as tight as imagined. There is an appreciable movement of air through a brick or cement block wall. Hence, all walls should be checked carefully at regular intervals for cracks, and fumigation should not be undertaken in windy or stormy weather. Cracks in masonry and around flashings can usually be best sealed by use of a good caulking compound, or a heavy, latex-based, plastic roofing compound. Care should be used to select a material which does not dry out and become hard. Better materials of this kind remain slightly soft and elastic for several years.

Newspaper pasted to the interior of a wall is not a satisfactory gas barrier. It will not prevent leakage of gas and should never be used. It may actually be worse than nothing, since it deceives the fumigator and results in loss of time, labor, and money. If paper is used, only a heavy kraft paper should be employed. For exterior use, a good material is a



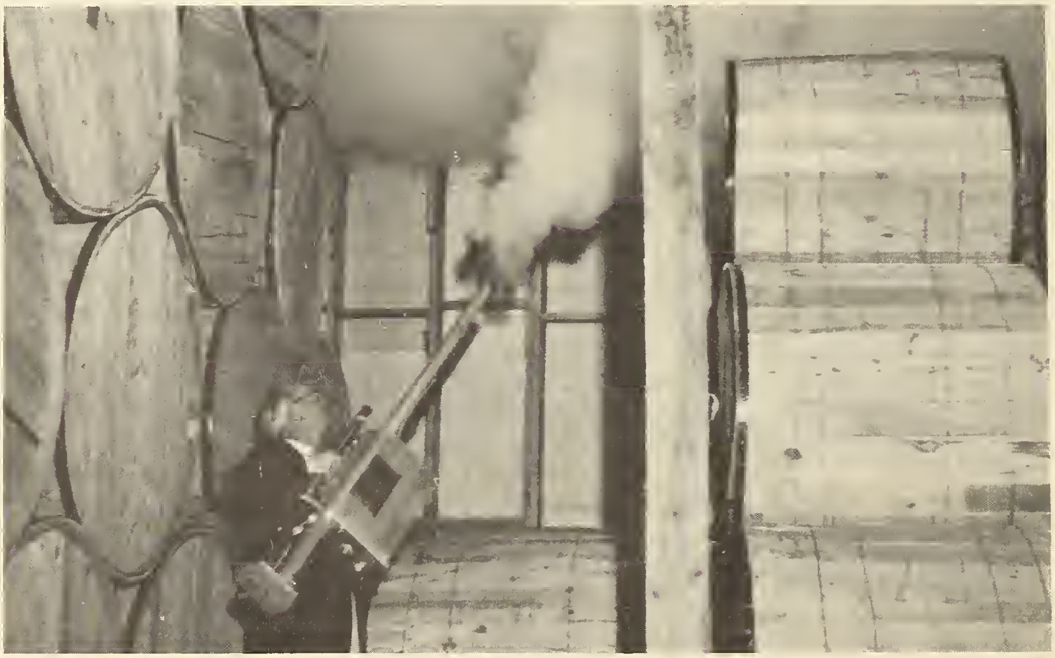
BN-8705

Figure 12.--A bad crack in masonry walls of atmospheric fumigation chamber shown in figure 8.



BN-5273

Figure 13.--Aerosol escaping at eaves shows leaks which must be sealed before fumigation is started.



BN-5265

Figure 14.--Using a portable thermal aerosol generator to locate leaks in a warehouse of flue-cured tobacco. Blast of fog is being directed to eaves.

laminated kraft paper, the adhesive of which is mineral asphalt. Such paper is an effective gas barrier. Masking tape of good quality is excellent for temporarily sealing small cracks. Such tape is not satisfactory for permanent sealing, and will not stand up for more than a few days, especially when exposed to rain or sun.

One good method of locating leaks in a building is by means of a portable thermal aerosol generator. The generator is filled with a light oil, and the blast of fog or smoke from the machine is directed against the interior surface of the suspected area of wall, eaves, or roof. The fog will penetrate the cracks, and a person outside the building can readily observe and mark the leak (8) (figs. 13 and 14). The most satisfactory oil for such use is a light, volatile, hydrocarbon oil such as is used as an insecticide base (10). For best results the aerosol should be very fine, the mass median diameter of the droplets being less than 1 micron.

PREPARATION OF BALES FOR FUMIGATION

The effectiveness of any atmospheric fumigation is largely dependent upon penetration of the gas into the tobacco. Of course, penetration depends, in part, upon concentration and retention of the gas, but various other factors may also interfere.

Bales of strips (lamina of tobacco leaf from which midribs have been removed) are usually packed with an inner wrapping of heavy paper completely covering the tobacco. Gas does not readily penetrate such a paper liner. Prior to fumigation, the burlap cover of lined bales must be opened at the ends, and the paper liner folded back. The bales can be closed and resewn after fumigation. It is most desirable to cover the bales of strips, when they are packed, in such a way as to permit better penetration of the gas. This can be accomplished by folding back the paper liner so as to leave a 2-inch strip along each side of the bale. The uncovered strip will permit much better penetration of the fumigant. The folding of the paper at the ends of the bales need not be changed in any way.

The same problem arises when palm fiber is used around a bale as when paper is used. Although the palm fiber is seldom as tight as paper, it is desirable to leave open strips along the side to facilitate penetration of the gas.

STORAGE OF TOBACCO AFTER FUMIGATION

A common mistake, after fumigation, is to store freshly fumigated tobacco in the same room with infested tobacco. Such a practice is a waste of time, money, and effort. Of course, the fumigated tobacco will be reinfested immediately. Fumigated tobacco should always be stored in a clean room or building. If possible, the room should be screened with 20-mesh wire gauze (11).

Several fumigants are used for tobacco. Each has advantages and disadvantages. The most commonly used are: hydrogen cyanide (HCN), methyl bromide, acrylonitrile-carbon tetrachloride mixture, and ethylene oxide-carbon dioxide mixture.

Hydrogen Cyanide

HCN is a lighter-than-air gas commonly used to fumigate cigarette tobaccos and, sometimes, cigar tobaccos. It is an excellent killing agent, is readily available, and, although a deadly poison gas, it has a good warning odor and is not cumulative in the human body. It can be handled with reasonable safety. It is usually shipped as a liquid in pressure cylinders. It can also be obtained absorbed in discs of cellulose material packed in sealed cans.

HCN has one serious disadvantage. It leaves a highly objectionable odor and taste on tobacco which may persist for several weeks. This is particularly marked in humid weather or with tobacco of high moisture content. This is not considered objectionable when tobacco is held for many months, since the odor will eventually disappear. It is highly objectionable for use just prior to manufacture or for finished cigars (8).

Methyl Bromide

Methyl bromide is a heavier-than-air gas sold in pressure cylinders. It is readily available, is highly effective, penetrates better than some fumigants, and is explosive or flammable only at excessive concentrations. It has three objectionable characteristics: it has little or no warning odor; very rarely, under some conditions, it has been known to impart an objectionable odor to cigar tobaccos; and it is cumulative in the human body, for short periods of time.

The poor warning odor may be overcome by incorporating 1 or 2 percent of chloropicrin in the formulation.

There is evidence that the development of objectionable odor or taint is due to a chemical reaction of the bromine with tobacco of unusually high protein nitrogen. This reaction is extremely rare, but it has occurred with Puerto Rican filler, Connecticut shade wrapper, and Havanna tobaccos. Unfortunately, there is no practical way of anticipating when such a reaction might occur. It is obviously impractical to make a chemical analysis of every lot of tobacco prior to fumigation.

CONTINUED EXPOSURE OF WORKMEN TO EVEN VERY LOW CONCENTRATIONS OF METHYL BROMIDE CAN BE DANGEROUS, because of the danger of its accumulating in the body. This is no reason to preclude its use, but the danger should be recognized (8).

Acrylonitrile-Carbon Tetrachloride 34-66 (by volume)

Acrylonitrile-carbon tetrachloride 34-66 (by volume) is a heavier-than-air gas that is used extensively for cigar tobaccos. It is highly effective, penetrates well at atmospheric pressure, has a good warning odor, is not cumulative in the human body, and has the faculty of airing out of tobacco faster than most fumigants. Manufacturers state that the formulation is not explosive or flammable at recommended dosages. It leaves no odor or taste that can be detected after a few hours. Consequently, this fumigant can be used safely on tobacco just prior to manufacture or on finished cigars. It is also slightly cheaper and a little less dangerous to human beings than most tobacco fumigants. It is shipped in standard metal drums, and is only slowly volatile at air temperatures.

It can, therefore, be used in the old open-pan method of fumigation. The pans should be large and shallow, and suspended near the ceiling. A satisfactory pan is approximately 24 by 36 by 4 inches, but should not be filled to a depth of over 2 inches. Burlap or cloth may be draped over and into the pans to act as a wick and increase the evaporative surface. A simple and satisfactory method of introducing the fumigant is to have a pipe running from a glass jug on the exterior of the chamber and discharging into each pan by gravity. A jug should be provided for each pan. The liquid fumigant should be measured into the jugs in the open air. It is a simple job for any laborer to pour the correct dosage into each pan. Galvanized iron pans will last for 2 or 3 years, but stainless steel pans are more permanent.

In handling the liquid fumigant, care should be taken to avoid spilling it on the body or breathing the fumes. If the liquid comes in contact with the skin, it should be washed off quickly with soap and water. Clothing that becomes contaminated with the liquid should be removed immediately and not worn again for several days.

Acrylonitrile has two undesirable characteristics. It dissolves rubber and destroys rubber hose and rubber gaskets; it also corrodes metals, especially iron or steel (8). Its corrosive effect on steel vacuum chambers has caused some difficulty. However, protective paints can be used on such chambers.

Ethylene Oxide-Carbon Dioxide 1-9

Ethylene oxide-carbon dioxide 1-9 has been used in vacuum fumigation of cigar tobaccos but has been replaced largely by acrylonitrile-carbon tetrachloride. It is not used in atmospheric fumigation. It leaves no odor or taste on the tobacco and is relatively safe to use, but it is quite expensive. It is sometimes erratic in effectiveness; this characteristic is believed to be due to a polymerization which takes place under certain conditions (8).

Carbon Disulphide

Carbon disulphide is one of the oldest, cheapest, and most effective tobacco fumigants. However, its use is no longer recommended because of the extreme danger of fire and explosion inherent in its use. It is rarely used today (8). Several warehouses of tobacco have been completely destroyed by explosions which occurred while using this fumigant, and in many places its use is forbidden by law.

Dosage and Exposure

The dosage rate and exposure time of the fumigant depend upon the method of fumigation, the kind of fumigant, and the packaging of the tobacco (8). Tables 1, 2, and 3 show the recommended dosage rates for the various methods of fumigation discussed previously.

In vacuum chamber fumigation, the exposure period is customarily 4 hours, although the fumigant is often left in the chamber overnight. In atmospheric chambers, the exposure period is 48 to 72 hours. In warehouse or space fumigation, or fumigation under tarpaulins, the exposure period is preferably 72 hours, but is sometimes shortened to 48 hours. The longer exposure will usually give slightly better results.

SPACE TREATMENTS

Pyrethrum Mists and Aerosols

In some buildings or under certain conditions, tobacco cannot be fumigated. It is often more desirable to kill the few beetles which constantly fly into a manufacturing or processing plant. In such places a contact insecticide can sometimes be used advantageously.

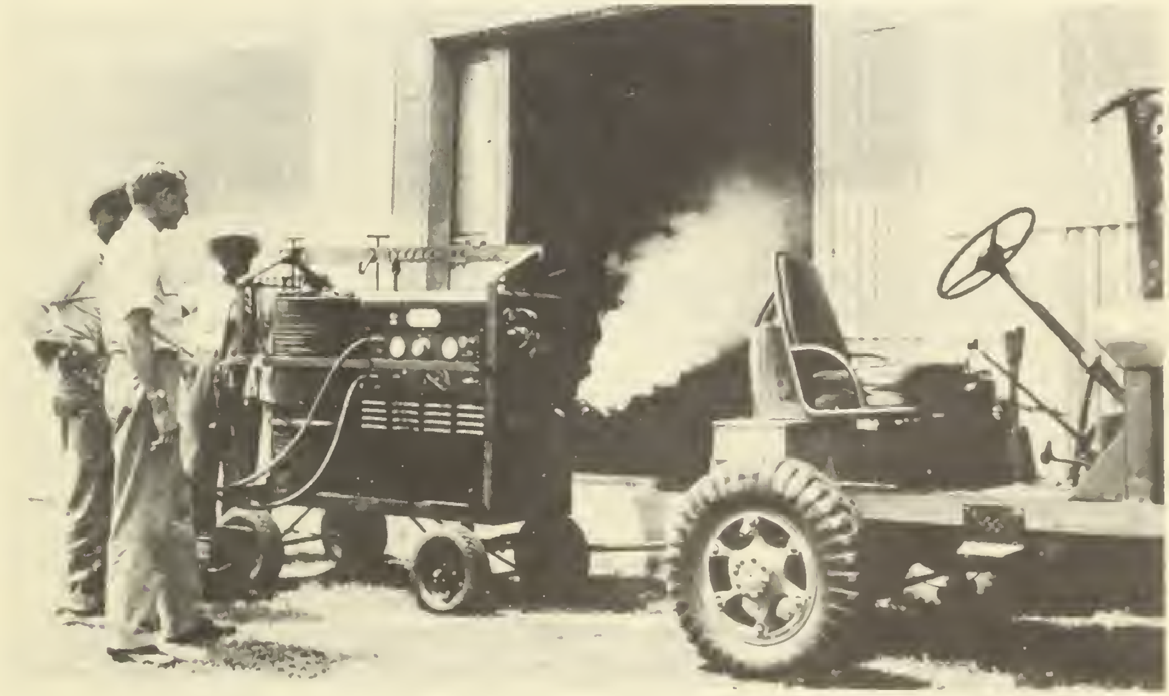
The cigarette beetle is harder to kill than many insects. A pyrethrum mist or aerosol of sufficient strength will kill the beetles that are hit by the spray particles. This type of treatment will not penetrate tobacco or cracks and crevices; it is only effective against insects in the airspace.

To be effective, the insecticide should contain 1 percent of pyrethrins in a light, highly volatile, hydrocarbon oil. The oil must leave no objectionable odor and no greasy deposit. Specifications for a suitable oil are as follows: Maximum specific gravity at 60° F., 0.77-0.80; flash point (Tag-closed cup) 140° minimum; initial boiling point 370° minimum; distillation end point 490° maximum; colorless; no kerosene or naptha odor, no residual odor.

Selection of a pyrethrum insecticide for use against the cigarette beetle should be based upon pyrethrins content. Many pyrethrum sprays contain a synergist or activator for the pyrethrum, such as piperonyl butoxide or sulfoxide of isosafrole. These synergists are excellent against many insects like houseflies or mosquitoes, but are of very little value against the cigarette beetle. Their inclusion in an insecticide is not objectionable, and they will not injure tobacco. However, not enough benefit is derived from any of the known synergists to justify their inclusion in a pyrethrum insecticide for use against the cigarette beetle.

Contact insecticides may be applied as a mist, a thermal aerosol, or a mechanically produced aerosol (fig. 15); each will kill the beetle. Better distribution can be obtained with an aerosol because of its finer particles. For satisfactory results, the airspace must be filled with the fog of insecticide; to do this, a dosage of 75 to 100 ml. per 1,000 cubic feet of airspace is required. Good results cannot be expected if a smaller quantity is used, or if the insecticide contains less than 1 percent pyrethrins (10).

In applying a pyrethrum mist or aerosol, care should be taken to avoid wetting any tobacco with the material. Pyrethrum insecticides have been used in tobacco storages and factories for nearly 20 years, and no instance has been reported of the mist or aerosol affecting tobacco. However, tobacco may be tainted by insecticide that is spilled or that condenses on metal pipes and drips on the tobacco. Becuase of this possibility, all unpackaged tobacco or cigars should be covered with cloth on paper prior to spraying or fogging.



BN-8704

Figure 15.--Introducing a pyrethrum thermal aerosol into a tobacco warehouse.

For best results, a pyrethrum aerosol should be applied at frequent intervals. Applications should start as soon as beetles are observed or suspected. They should be made at least weekly, and can be made daily. Frequency of application will depend upon various factors such as value of product, need of protection, or amount of infestation. Usually, however, little advantage can be gained by fogging more than two or three times a week.

All applications should be made between 5 p.m. and midnight; this is when most of the beetles are flying. During the working day, relatively few beetles are out where the insecticide can reach them.

It is well to keep in mind just what can and what cannot be expected of a pyrethrum aerosol or mist. When an adequate formulation is properly applied it will:

1. Kill most of the beetles flying in the airspace.
2. Kill many of the beetles before they have an opportunity to lay eggs, thus often preventing eggs being deposited on tobacco or cigars.
3. Kill newly hatched larvae if they are on the surface of the tobacco where they are exposed to the insecticide. (Most of the larvae are under the surface.)
4. Often prevent a build-up of beetle population.
5. Be safe for anyone entering the treated area even when the air is filled with the pyrethrum fog. (Pyrethrum is not dangerous to most people, but there is a very rare individual who is allergic to this material.)

It will not:

1. Kill beetles or large larvae or pupae in the tobacco.
2. Prevent hatching of beetle eggs.
3. Prevent beetles depositing some eggs.
4. Be effective for more than an hour. (Pyrethrum has little or no residual action against the cigarette beetle.)
5. Control a heavy beetle infestation; it cannot be depended upon to eliminate a light infestation.
6. Damage tobacco unless the liquid is spilled or dripped on it.
7. Be explosive at the dosages recommended. Pyrethrum-in-oil mists and aerosols have been approved by the fire insurance underwriters in the United States for use in tobacco warehouses when proper precautions are observed. However, all oils are flammable, and most oil-based aerosols are theoretically explosive at high concentrations. For this reason, SMOKING OR THE USE OF OIL OR GASOLINE LAMPS OR LANTERNS SHOULD BE FORBIDDEN IN AND AROUND BUILDINGS WHERE SUCH INSECTICIDES ARE BEING APPLIED. NEVER TAKE A THERMAL AEROSOL GENERATOR INSIDE A BUILDING TO APPLY AN AEROSOL.

DDVP

A new insecticide, usually called "DDVP", has been used extensively since 1957 (12, 13). This material is a phosphate insecticide, 2, 2-dichlorovinyl dimethyl phosphate. It has some unusual properties and can sometimes be used to advantage.

DDVP is generally applied as an aerosol in an oil-based formulation. When applied in a warehouse, DDVP kills by contact, and the deposit of insecticide releases a vapor which continues to kill for several days. The insecticide volatilizes completely in about 2 weeks and leaves no residue. The vapor will kill adult cigarette beetles and young larvae; it will destroy the viability of eggs in the later stages of incubation if they are exposed in the airspace. It will not penetrate piles, bulks, bales, or cases and is relatively ineffective against large larvae and pupae, even in the airspace.

Because this material will kill for several days, it is more effective than a contact insecticide which kills only during the few minutes its particles are suspended in the air. However, this continuous killing action depends upon maintaining a lethal concentration of vapor in the air of the room, a condition which cannot be maintained in a ventilated building. Currents of air carry out the vapor and dissipate it. Because of this, DDVP is of little value except in a closed building.

Many buildings in the tropics have windows or openings which cannot be closed readily. In such places, DDVP would not be practical. For effective use of DDVP, a building does not have to be sealed as it does for fumigation. It can have an appreciable number of cracks, but there must be no currents of air.

The recommended dosage is 2 grams of actual DDVP per 1,000 cubic feet. For maximum effectiveness, the aerosol should be applied twice a week.

DDVP may also be applied by sprinkling it on a wooden floor or on boards laid over concrete. IT SHOULD NEVER BE APPLIED DIRECTLY ON CONCRETE, as a chemical reaction occurs which reduces its effectiveness. When sprinkled on a wooden surface, DDVP may be applied as a concentrate; a 50-percent water emulsifiable concentrate is preferred. The dosage recommended for this method of treatment is the same as when an aerosol is used--2 gm. per 1,000 cubic feet.

One problem with DDVP is that it is hazardous to handle. CARE MUST BE OBSERVED TO AVOID GETTING THE LIQUID ON THE SKIN OR CLOTHING. IF IT IS SPILLED, CONTAMINATED CLOTHING SHOULD BE REMOVED IMMEDIATELY AND NOT WORN AGAIN UNTIL THOROUGHLY AIRED AND CLEANED. IF IT IS SPILLED ON THE BODY, IT SHOULD BE WASHED OFF IMMEDIATELY WITH LIBERAL AMOUNTS OF SOAP AND WATER. FURTHERMORE, NO ONE SHOULD EVER ENTER A BUILDING TREATED WITH DDVP AEROSOL UNTIL THE FOG HAS SETTLED--USUALLY 2 TO 3 HOURS AFTER APPLICATION. BREATHING THE FOG IS VERY DANGEROUS.

However, after the aerosol has settled, laborers can safely enter the building and work continuously for 8 hours a day (12). In industrial treatment of tobacco warehouses with DDVP, it is customary to apply the insecticide in the evening after working hours. By the next morning, it is entirely safe for laborers to enter and work as usual.

BECAUSE OF THE DANGERS INVOLVED IN HANDLING AND APPLYING THIS INSECTICIDE, IT SHOULD BE APPLIED BY A QUALIFIED PEST CONTROL OPERATOR.

CONTROL WITH TEMPERATURE

Cold and Cool Storage

The cigarette beetle does not feed, grow, or breed at temperatures below 60° F. Therefore, a cool storage room is very valuable if tobacco is to be held for any length of time. With modern air-conditioning equipment, a cool storage room is not too expensive. Of course, tobacco does not sweat at low temperatures, so as a rule only sweated tobacco or finished cigars are held in cool storage.

One tobacco company in the United States stores large quantities of cigarette tobacco at 60° - 65° F. A well-known cigar manufacturer stores sweated wrapper at 47° - 48° with 58 percent relative humidity. Another large cigar manufacturer stores finished cigars at 34° - 35° with 80 percent relative humidity (9).

The cigarette beetle is rather susceptible to cold and may be killed by exposure to low temperature. In general, the lower the temperature the shorter the exposure necessary to produce mortality, although some stages of the insect are more quickly killed than others. At 47° - 48° F., all larvae were killed in 95 days, and the last pupa died in 109 days, but the viability of eggs was destroyed in 13 days. All stages of the beetle were killed at 36° in 16 days; at 15° in 60 hours; and at 10° in 1 hour (6, 9). However, tobacco is exceptionally good insulating material. Consequently, the time necessary for the cold to penetrate the tobacco must be added to the time necessary to kill the insect. This may require several days.

In the United States, low temperature has been used as a substitute for fumigation. Sweated or unsweated tobacco (filler, binder, and wrapper) are subjected to -10° F., for 3 to 5 days. At -10°, practical control of the beetle is obtained in 3 days in cases and bales of wrapper and binder and carton-enclosed bales of shade wrapper. All beetle infestation is eliminated in 5 days, even in the center of cases and bales.

When tobacco is exposed to low temperature, airspaces should be left over, under, between, and around the bales and cases, to facilitate penetration of the cold. They should never be stacked together in a solid mass.

Heat

Heat also can be used to free tobacco of all insect life. However, heat is seldom, if ever, used except just before manufacture. One cigar company in the United States uses a steam conditioning and sterilizing treatment for bales of low-grade Puerto Rican filler. Live steam is injected into the bales at a pressure of 125 pounds per square inch for 30 minutes. Tests have shown that 10 minutes after the end of the treatment the interior temperature of the bales was 220° F., and after 30 minutes, 240°. Eighteen hours after treatment, the temperature of the center of the bales was 155°. This treatment gave complete kills of all stages of the cigarette beetle and left the tobacco in excellent order for handling and manufacture.

The temperatures used in forced sweat rooms are not high enough to kill the cigarette beetle. This insect has been reared through two complete generations in a sweat room maintained at 110° F. and 95 percent relative humidity.

Table 1.--Recommended dosages of fumigants in the vacuum fumigation of tobacco at 70° F. or above, with an exposure of 4 hours

Kind of tobacco	Dosage per 1,000 cubic feet			
	Hydrogen cyanide	Methyl bromide	Acrylonitrile-carbon tetrachloride 34-66	Ethylene oxide-carbon dioxide 1-9
	Pounds	Pounds	Pounds	Pounds
Filler or binder in bales or cases	4	4	4	60
Shade wrapper in bales	5	-	5	65
Cigars in open presses	-	-	4	60
Cigars in boxes and sealed cartons	-	-	5	65

Table 2.--Recommended dosages of fumigants for cigar tobaccos in atmospheric chambers at 70° F. or above, with an exposure of 48 hours or more

Kind of tobacco	Dosage per 1,000 cubic feet		
	Hydrogen cyanide	Methyl bromide	Acrylonitrile-carbon tetrachloride 34-66
	Pounds	Pounds	Pounds
Filler or binder in bales or cases.........	1	1½	3 to 4
Wrapper in bales.........	1½	-	4
Shade wrapper in bale plus carton............	2	-	5
Cigars in open press.....	-	-	3
Cigars in boxes and in sealed cartons.........	-	-	5

Table 3.--Recommended dosages of fumigants for cigar tobaccos in warehouses or under tarpaulins at 70° F. or above, with exposures from 48 to 72 hours

Kind of tobacco or type of building	Dosage per 1,000 cubic feet		
	Hydrogen cyanide	Methyl bromide	Acrylonitrile-carbon tetrachloride 34-66
	Pounds	Pounds	Pounds
Filler or binder in bales or cases.........	1 to 1¼	1½ to 2	3½ to 5
Filler or binder in bulks	1/1 to 2	1/1½ to 2	1/3½ to 5
Wrapper in bales.........	1 to 2	-	3½ to 5
Shade wrapper baled and in carton.............	1 to 2	-	4 to 5
Factory or processing plant..................	1 to 1½	1¼ to 4	4 to 5

1/ Exposure period 72 hours.

LITERATURE CITED

(1) Powell, T. E., Jr.
1931. An Ecological Study of the Tobacco Beetle, *Lasioderma serricorne* Fabr., with Special Reference to Its Life History and control. Ecol. Monog. 1: 333-393.

(2) Reed, W. D. and Morrill, A. W. Jr.
1935. Trapping Experiments for the Control of the Cigarette Beetle. U. S. Dept. Agr. Cir. 356, 13 pp., illus.

(3) __________ and Vinzant, J. P.
1942. Control of Insects Attacking Stored Tobacco and Tobacco Products. U. S. Dept. Agr. Cir. 635, 40 pp., illus.

(4) Runner, G. A.
1919. The Tobacco Beetle: An Important Pest in Tobacco Products. U. S. Dept. Agr. Bul. 737, 77 pp., illus.

(5) Sivik, F. P., Tenhet, J. N., and Delamar, C. D.
1957. An Ecological Study of the Cigarette Beetle in Tobacco Storage Warehouses. Jour. Econ. Ent. 50 (3): 310-316.

(6) Swingle, M. C.
1938. Low Temperature as a Possible Means of Controlling the Cigarette Beetle in Stored Tobacco. U. S. Dept. Agr. Cir. 462, 8 pp.

(7) Tenhet, J. N.
1955. Timing of Sprays to Control the Cigarette Beetle. U. S. Dept. Agr. AMS-49 6 pp. Processed .

(8) __________
1957. Tobacco Fumigants and Fumigation. Tobacco 144 (12): 22-26.

(9) __________
1957. Cold Storage and Cool Storage of Tobacco to Control the Cigarette Beetle. Tobacco 145 (19): 20-25 (Tobacco Science 1: 169-174).

(10) __________
1959. Pyrethrum Mists and Aerosols for the Control of Insects in Tobacco Warehouses. U. S. Dept. Agr., Agr. Mktg. Serv., Mktg. Res. Rept. 334, 21 pp.

(11) __________ and Bare, C. O.
1951. Control of Insects in Stored and Manufactured Tobacco. U. S. Dept. Agr. Cir. 869, 32 pp., illus.

(12) __________, Bare, C. O., and Childs, D. P.
1958. Further Studies on the Control of the Cigarette Beetle with DDVP. Tobacco Sci. 147 (6): 106-110.

(13) __________, Bare, C. O., Childs, D. P., and Durham, W. F.
1957. Studies of DDVP for Control of the Cigarette Beetle in Tobacco Warehouses. U. S. Dept. Agr., Agr. Mktg. Serv., AMS-214, 15 pp. Processed .

OTHER PUBLICATIONS ON STORED-PRODUCT INSECTS

AMS-4 Fumigation of Dry Beans and Cowpeas on the Packaging Line. Jan. 1955.

AMS-5 Procedure for the Fumigation of Dry Beans and Cowpeas on the Packaging Line. Jan. 1955.

AMS-49 Timing of Sprays to Control the Cigarette Beetle. May 1955.

AMS-58 An Insect Preventive Program for Peanut Warehouses. June 1955.

AMS-64 Protecting Stored Seed from Insect Attack. (Revision of publication E-677, issued December 1945.) July 1955.

AMS-73 Effect of Varying the Volatilization of Methyl Bromide by Combinations with Various Solvents on its Distribution in Bulk Grain Fumigation. Dec. 1955.

AMS-101 Studies on Separation of Weevil-infested from Noninfested Wheat by Flotation. March 1956.

AMS-131 Enclosures for Fumigating Stored Raisins. July 1956.

AMS-150 Experiments on Distributing Methyl Bromide in Bulk Grains with Aeration System. Jan. 1957.

AMS-151 Experiments on Distributing Liquid Fumigants in Bulk Grains with Aeration Systems. Jan. 1957.

AMS-152 Experiments on Distributing HCN in Bulk Grain with Aeration System. Jan. 1957.

AMS-214 Studies of DDVP for Control of Cigarette Beetles in Tobacco Warehouses. Nov. 1957.

AMS-218 Observations of the Effect of Packaging Temperature of Nonfat Dry Milk on Insects in the Containers. Nov. 1957.

AMS-273 Control of Insects that Attack Dried Beans and Peas in Storage. Aug. 1958.

AMS-302 Insect Prevention and Control in Plants Processing Dry Milk. April 1959.

AMS-337 Suggestions for Insect Control in Farmers Stock Peanuts. Sept. 1959.

AMS-343 A Cleaner for Removing Insects from Raisins. Oct. 1959.

AMS-390 A Summary of Information about the Khapra Beetle. July 1960.